PB-239 595

WATERFORD IMPOUNDMENT - TICHIGAN LAKE, RACINE COUNTY, WISCONSIN

Pacific Northwest Environmental Research Laboratory

Prepared for:

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Wisconsin Department of Natural Resources
Wisconsin National Guard

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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REPORT

ON

WATERFORD IMPOUNDMENT-TICHIGAN LAKE

RACINE COUNTY

WISCONSIN

EPA REGION V

WORKING PAPER No. 52

WITH THE COOPERATION OF THE

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

AND THE

WISCONSIN NATIONAL GUARD

NOVEMBER, 1974

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Wisconsin Department of Natural Resources for professional involvement and to the Wisconsin National Guard for conduct of the tributary sampling phase of the Survey.

Francis H. Schraufnagel, Acting Assistant Director, and Joseph R. Ball of the Bureau of Water Quality, and Donald R. Winter, Lake Rehabilitation Program, provided invaluable lake documentation and counsel during the Survey. Central Office and District Office personnel of the Department of Natural Resources reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper series.

Major General James J. Lison, Jr., the Adjutant General of Wisconsin, and Project Officer CW-4 Donald D. Erickson, who directed the volunteer efforts of the Wisconsin National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

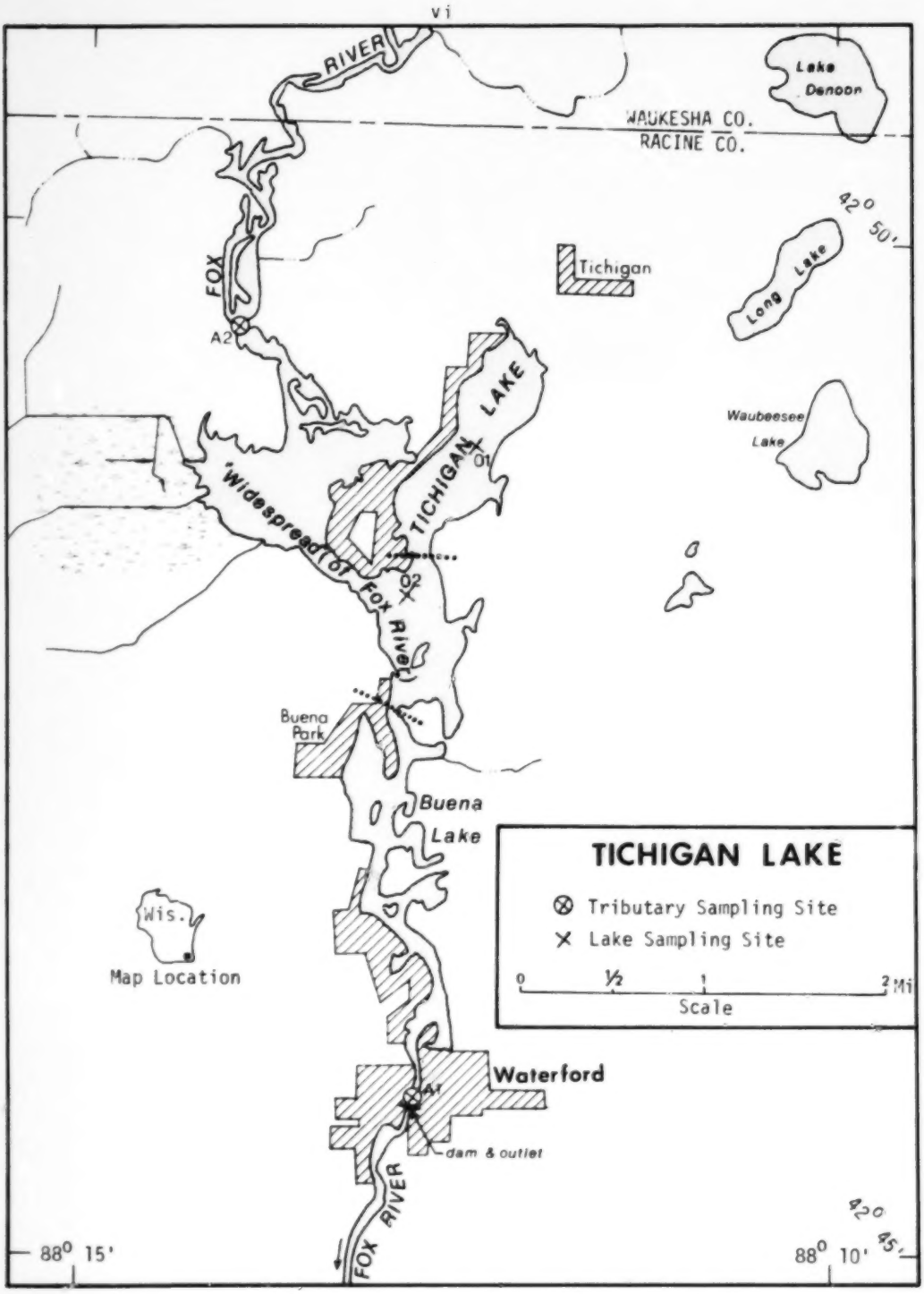
NATIONAL EUTROPHICATION SURVEY

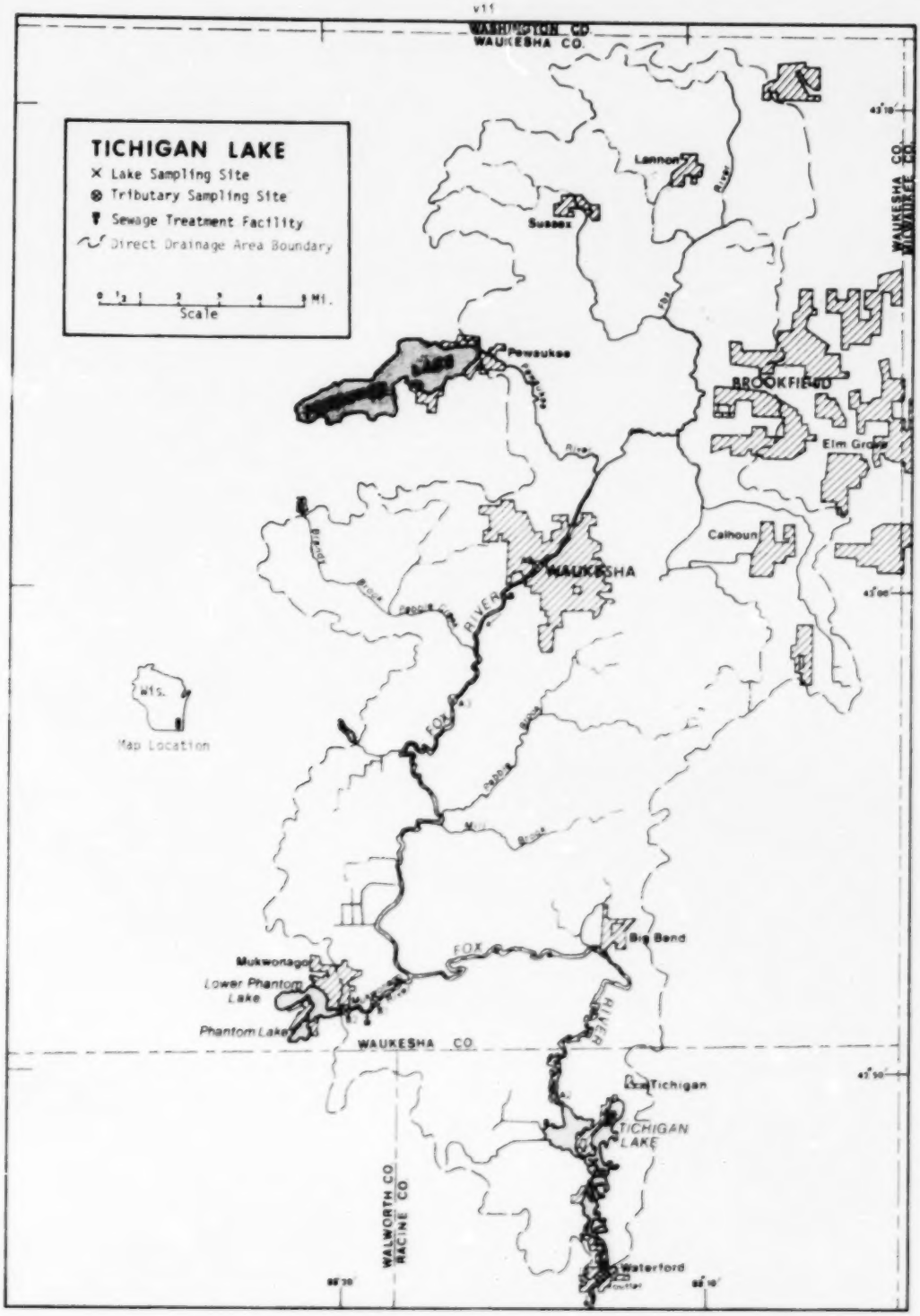
STUDY LAKES

STATE OF WISCONSIN

LAKE NAME	COUNTY
Altoona	Eau Claire
Beaver Dam	Barron
Beaver Dam	Dodge
Big Eau Pleine	Marathon
Browns	Racine
Butte des Morts	Winnebago
Butternut	Price, Ashland
Castle Rock Flowage	Juneau
Como	Walworth
Crystal	Vilas
Delavan	Walworth
Eau Claire	Eau Claire
Geneva	Walworth
Grand	Green Lake
Green	Green Lake
Kegonsa	Dane
Koshkonong	Jefferson, Rock, Dane
Lac La Belle	Waukesha
Middle	Walworth
Nagawicka	Waukesha
Oconomowoc	Waukesha
Okauchee	Waukesha
Petenwell Flowage	Juneau
Pewaukee	Waukesha
Pigeon	Waupaca
Pine	Waukesha
Poygan	Winnebago, Waushara
Rock	Jefferson
Rome Pond	Jefferson, Waukesha
Round	Waupaca
Shawano	Shawano

LAKE NAME	COUNTY
Sinnissippi	Dodge
Swan	Columbia
Tainter	Dunn
Tichigan	Racine
Townline	Oneida
Trout	Vilas
Wapogassett	Polk
Wausau	Marathon
Willow	Oneida
Winnebago	Winnebago, Fond Du Lac, Calumet
Wisconsin	Columbia
Wissota	Chippewa
Yellow	Burnett


FOX RIVER
Lake Denoon
WAUKESHA CO.
RACINE CO.
42° 50'
Tichigan
Long Lake
FOX
A2
TICHIGAN LAKE
Waubeesee Lake
01
Widespread of Fox River
02
Buena Park
Buena Lake
Wis.
Map Location
TICHIGAN LAKE
Tributary Sampling Site
Lake Sampling Site
0 ½ 1 2 Mi
Scale
Waterford
A1
dam & outlet
FOX RIVER
42° 45'
88° 15'
88° 10'


TICHIGAN LAKE
Lake Sampling Site
Tributary Sampling Site
Sewage Treatment Facility
Direct Drainage Area Boundary
Scale
Wis.
Map Location
WASHINGTON CO
WAUKESHA CO
Lannon
Sussex
Pewaukee
BROOKFIELD
Elm Grove
Calhoun
WAUKESHA
FOX RIVER
Mukwonago
Lower Phantom Lake
Phantom Lake
Big Bend
WAUKESHA CO
Tichigan
TICHIGAN LAKE
WALWORTH CO
RACINE CO
Waterford

WATERFORD IMPOUNDMENT-TICHIGAN LAKE

STORET NO. 5559

I. CONCLUSIONS

A. Trophic Condition:

Survey data and the records of others show that the Tichigan Lake basin and the rest of the Waterford Impoundment are highly eutrophic waters.

B. Rate-Limiting Nutrient:

The algal assay results show that the composited assay sample was nitrogen limited. The lake data show nitrogen limitation at all sampling times in Tichigan Lake and in the Widespread.

C. Nutrient Controllability:

1. Point sources--During the sampling year, the Waterford Impoundment-Tichigan Lake system received a phosphorus load at a rate far in excess of that proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 17). Of this load, it is calculated that the communities of Waukesha and Mukwonago contributed nearly 84%.

In the following table, the total phosphorus loading rates that can be achieved by specified levels of phosphorus removal at Waukesha and Mukwonago are shown and compared to Vollenweider's suggested loading rates.

% P Removal	Total P Loading lbs/acre/yr	Total P Loading $g/m^2/yr$
Existing	183.0	20.51
50	106.5	11.94
70	75.9	8.51
80	60.6	6.79
90	45.3	5.07
100	30.0	3.36
Vollenweider:		
"Dangerous" (eutrophic rate)		1.16
"Permissible" (oligotrophic rate)		0.58

It will be noted that none of the removal options would reduce the phosphorus loading rate to an acceptable level, if it is assumed that all of the phosphorus from the indicated point sources reaches the water body. Note that the non-point source load attributed to the Fox River provided a loading rate of 28 lbs P/lake acre/yr or 3.14 $g/m^2/yr$, and thus non-point source loading rates alone would exceed the "dangerous" rate.

The Wisconsin Department of Natural Resources is now requiring phosphorus control at all of the municipal point sources in the Fox (Illinois) River basin. It would be expected that such control would at least result in a reduction in the incidence of nuisance algal blooms in the Waterford Impoundment-Tichigan Lake complex. However, since only 8% of the complex area is more than 20 feet deep (Poff, et al., 1970), rooted aquatic vegetation probably will continue to be a problem.

2. Non-point sources (see page 17)--It is estimated that non-point sources contributed about 16% of the total phosphorus load during the sampling year. Nutrient loads in the tributaries of other study lakes in the Fox (Illinois) River drainage were not determined, but the Fox River phosphorus export estimated using the dolomitic mean (see page 13) compares quite well to exports measured in other stream systems in Wisconsin.

The very high phosphorus export of the Fox River measured at station A-4 in Waukesha is believed to be due to the contributions of three point sources beyond the 25-mile limit of the Survey.

II. INTRODUCTION

The Waterford Impoundment-Tichigan Lake complex was formed by the impoundment of the Fox (Illinois) River at the Village of Waterford. The rise in water level due to the 8-foot-head dam submerged the outlet of naturally occurring Tichigan Lake, and the lake basin is now broadly joined with the rest of the system.

The complex now includes three more or less distinct parts: (1) The Tichigan Lake basin--268 acres, maximum depth 63 (68?*) feet; (2) the "Widespread" (of the Fox River)--623 acres, maximum depth ca. 5 feet; and (3) Buena Lake--241 acres, maximum depth 8 feet. The approximate limits of the three parts are indicated by the dotted lines on the map (page vi).

Apparently, the Widespread and the lake basin are now considered to be "Tichigan Lake" (several publications state that the area of the lake is 891 acres; i.e., the sum of the two areas; and Buena Lake is listed separately). However, this report is concerned with the entire complex, although it is noted that lake sampling was limited to the Tichigan basin and the Widespread.

Although the Waterford dam was originally constructed to provide for flood control and low-flow augmentation, reportedly the structure is no longer capable of water level regulation. Present uses of the impoundment are recreational and include swimming, boating, and fishing. Game fish present are northern pike, walleyes, largemouth bass, white bass, channel

* Survey limnologists reported sampling at depths of 64 and 65 feet and a total depth of 68 feet.

catfish, and panfish. Reportedly, the system provides one of the most versatile warmwater fisheries in southeastern Wisconsin, although carp are abundant and cause management problems (Poff, et al., 1970).

Except for the Tichigan basin, public access is good; public access to Tichigan is afforded only by way of the navigable former lake outlet (Poff and Threinen, 1961).

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry*:

1. Surface area: 1,133 acres.
2. Mean depth: 6.3 feet.
3. Maximum depth: 63 feet.
4. Volume: 7,113 acre/feet.
5. Mean hydraulic retention time: 19 days.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area†	Mean flow†
Fox River	334.0 mi^2	179.2 cfs
Mukwonago River**	(80.0 mi^2)	(48.0 cfs)
Minor tributaries & immediate drainage -	20.2 mi^2	11.2 cfs
Totals	354.2 mi^2	190.4 cfs

2. Outlet -

Fox River	356.0 mi^{2}††	190.4 cfs

C. Precipitation†††:

1. Year of sampling: 38.7 inches.
2. Mean annual: 31.5 inches.

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* Poff, et al., 1970.
† Drainage areas are accurate within ±0.5%; mean daily flows are accurate within ±40%; mean monthly flows are accurate within ±35%; and normalized monthly flows are accurate within ±35%.
** Included in Fox River area and flow.
†† Includes area of lake.
††† See Working Paper No. 1. "Survey Methods".

IV. LAKE WATER QUALITY SUMMARY

Tichigan Lake and the Widespread were sampled three times during the open-water season of 1972. Each time, samples for physical and chemical parameters were collected from one or more depths at one station on the lake and one on the Widespread (see map, page vi). During each visit, a single depth-integrated (15 feet or near bottom to surface) sample was composited from the two stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. Maximum depths sampled were 65 feet at station 1 and 4 feet at station 2.

The results obtained are presented in full in Appendix B, and the data for the fall sampling are summarized below. Note, however, the Secchi disc summary is based on all values. A comparison of the data obtained at the two stations during the November sampling, when Tichigan Lake was well mixed, demonstrates that there were significant differences in all parameters except for the phosphorus species. Similar differences are evident in surface samples taken in June and in August. Water quality in the Widespread obviously reflects the quality of the incoming Fox River, but Tichigan Lake apparently is much less affected. Possibly ground water recharge is a more important factor in the quality of the lake.

In any case, separate summaries of the fall data are presented below for the two stations. For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

1. Tichigan Lake -

		FALL VALUES (11/10/72)		
Parameter	Minimum	Mean	Median	Maximum
Temperature (Cent.)	7.6	7.7	7.7	7.7
Dissolved oxygen (mg/l)	10.2	10.7	10.6	11.1
Conductivity (μmhos)	560	565	560	580
pH (units)	8.4	8.5	8.5	8.5
Alkalinity (mg/l)	148	169	166	192
Total P (mg/l)	0.226	0.247	0.255	0.259
Dissolved P (mg/l)	0.187	0.193	0.190	0.208
NO_2 + NO_3 (mg/l)	0.190	0.202	0.200	0.230
Ammonia (mg/l)	0.540	0.565	0.550	0.650
		ALL VALUES		
Secchi disc (inches)	33	35	35	36

2. The Widespread -

Parameter	Minimum	Mean	Median	Maximum
Temperature (Cent.)	6.3	6.3	6.3	6.3
Dissolved oxygen (mg/l)	8.9	8.9	8.9	8.9
Conductivity (μmhos)	750	750	750	750
pH (units)	7.6	7.6	7.6	7.6
Alkalinity (mg/l)	284	292	292	300
Total P (mg/l)	0.236	0.245	0.245	0.254
Dissolved P (mg/l)	0.202	0.204	0.204	0.206
NO_2 + NO_3 (mg/l)	1.090	1.140	1.140	1.190
Ammonia (mg/l)	0.090	0.095	0.095	0.100
		ALL VALUES		
Secchi disc (inches)	12	12	12	12

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/21/72	1. Stichococcus	5,217
	2. Cyclotella	2,645
	3. Navicula	906
	4. Nitzschia	471
	5. Synedra	435
	Other genera	2,500
	Total	12,174
08/17/72	1. Cyclotella	4,529
	2. Synedra	870
	3. Oocystis	761
	4. Dinobryon	688
	5. Scenedesmus	434
	Other genera	2,464
	Total	9,746
11/10/72	1. Cyclotella	213
	2. Stephanodiscus	152
	3. Fragilaria	90
	4. Phacus	72
	5. Navicula	65
	Other genera	258
	Total	850

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/21/72	01 (Tichigan Lake)	15.4
	02 (Widespread)	107.1
08/17/72	01	12.1
	02	28.9
11/10/72	01	79.9
	02	24.7

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.126	0.890	22.7
0.006 P	0.132	0.890	22.5
0.012 P	0.138	0.890	22.5
0.024 P	0.150	0.890	22.5
0.060 P	0.186	0.890	22.0
0.060 P + 10.0 N	0.186	10.890	95.7
10.0 N	0.126	10.890	69.3

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity was at a very high level at the time the composite sample was collected.

The assay also shows that the sample was nitrogen limited. Note that the addition of increments of phosphorus did not

result in an increase in yield, but the addition of only nitrogen or nitrogen with phosphorus resulted in significantly greater yields than the control yield.

The data obtained at the two stations also indicate nitrogen limitation at the other sampling times as well.

D. Trophic Condition:

Survey data and the records of others show that the entire Waterford complex is highly eutrophic.

Of the 46 Wisconsin water bodies studied, none had a higher mean total phosphorus, none had a higher mean inorganic nitrogen, only one had more mean chlorophyll a, and only two lakes had a higher algal assay control yield.

V. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Wisconsin National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vii), except for the high runoff months of April and May when two samples were collected. Sampling was begun in September, 1972, and was completed in August, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year for the Fox River sites nearest the lake and the mean Mukwonago River flow were provided by the Wisconsin District Office of the U.S. Geological Survey.

In this report, nutrient loads in the Fox and Mukwonago rivers were calculated using mean concentrations and mean flows. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by determining the nutrient loads, in lbs/mi^2/year, in the Mukwonago River at station B-2 and multiplying by the ZZ area in mi^2.

The operator of the Waukesha wastewater treatment plant provided monthly effluent samples and corresponding flow data. The Village of Mukwonago declined participation in the Survey, and loads from there were estimated using nutrient and flow data obtained by the Department of Natural Resources in August, 1970 (McKersie, et al., 1972).

Three other municipalities--Brookfield, Pewaukee, and Sussex--are located upstream from the Waterford-Tichigan system beyond the 25-mile

limit of the Survey*. While nutrient loads from these sources are not included in the following tables, they are evident in the nutrient export loads of the Fox River at station A-4 in Waukesha (see page 17).

In the following loading tables, all of the nutrient loads measured at Waukesha and estimated for Mukwonago are assumed to have reached the Waterford complex during the sampling year. However, the amount of effluent phosphorus measured at the Waukesha STP alone exceeded that measured at the Fox River at the inlet station (A-2); and the areal or non-point phosphorus load indicated for the Fox River was calculated with mean flows and the regional dolomitic mean total phosphorus concentration as determined by the Department of Natural Resources (Poff, et al., 1970; page 7).

The nitrogen load attributed to the Fox River is the amount measured at station A-2 minus the loads attributed to the Waukesha and Mukwonago treatment plants.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served**	Treatment	Mean Flow (mgd)	Receiving Water
Waukesha	40,258	Trickling filter	10.080	Fox River
Mukwonago	2,367	Trickling filter	0.156***	Mukwonago River

* See Working Paper No. 1.
** 1970 Census.
*** McKersie, et al., 1972.

2. Industrial* - Only two industries of nutrient significance are located in the drainage. One of these, the Mammoth Springs Canning Corporation, disposes of wastes by a lagoon-spray irrigation system with no discharge; the other is a small ice-cream factory, Keystone Farms, with a septic tank-stabilization pond system discharging to Pebble Creek about 35 stream miles upstream from Tichigan Lake.

* McKersie, et al., 1972.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Fox River	31,750	15.3
b. Minor tributaries & immediate drainage (non-point load) -	1,680	0.8
c. Known municipal -		
Waukesha	166,260	80.2
Mukwonago	7,130	3.4
d. Septic tanks* -	350	0.2
e. Industrial - Unknown	?	-
f. Direct precipitation** -	180	0.1
Total	207,350	100.0

2. Outputs -

Lake outlet - Fox River 120,690

3. Net annual P accumulation - 86,660 pounds

* Estimated 550 dwellings and 2 parks on lakeshore; see Working Paper No. 1.
** See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
Fox River	514,080	55.7
b. Minor tributaries & immediate drainage (non-point load) -	42,370	4.6
c. Known municipal -		
Waukesha	330,140	35.8
Mukwonago	11,740	1.3
d. Septic tanks* -	13,080	1.4
e. Industrial - Unknown	?	-
f. Direct precipitation** -	10,920	1.2
Total	922,330	100.0

2. Outputs -

Lake outlet - Fox River 835,860

3. Net annual N accumulation - 86,470 pounds

* Estimated 550 dwellings and 2 parks on lakeshore; see Working Paper No. 1.
** See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Fox River at A-2*	95	1,539
Fox River at Waukesha** (station A-4 above STP)	304	2,709
Mukwonago River	76	1,926

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Units	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
lbs/acre/yr	183.0	76.5	814.1	76.3
grams/m^2/yr	20.51	8.57	91.2	8.6

Vollenweider loading rates for phosphorus (g/m^2/yr) based on mean depth and mean hydraulic retention time of Waterford-Tichigan Lake:

"Dangerous" (eutrophic rate)	1.16
"Permissible" (oligotrophic rate)	0.58

* Dolomitic mean x A-2 flow.

** Nine-year mean flow at U.S.G.S. gage (Anonymous, 1974; page 151) x A-4 concentrations.

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VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR WISCONSIN 9/30/74

LAKE CODE 5559 TICHIGAN LAKE

TOTAL DRAINAGE AREA OF LAKE 356.00

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
5559A1	356.00	140.70	160.90	552.90	372.00	241.30	181.00	110.60	84.40	86.50	110.50	130.70	110.60	190.39
5559A2	334.00	130.00	150.00	520.00	350.00	230.00	170.00	100.00	78.00	80.00	110.00	120.00	110.00	179.23
5559ZZ	22.00	6.40	8.80	32.00	26.00	19.00	11.00	6.10	3.80	4.40	5.80	4.70	5.80	11.17

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 356.00
SUM OF SUB-DRAINAGE AREAS = 356.00

TOTAL FLOW IN = 2281.80
TOTAL FLOW OUT = 2282.10

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
5559A1	9	72	860.00	23	1900.00				
	10	72	650.00	23	760.00				
	11	72	430.00						
	12	72	210.00	4	240.00	18	180.00		
	1	73	510.00						
	2	73	350.00	11	390.00				
	3	73	670.00	6	760.00				
	4	73	1300.00	16	1500.00	20	990.00		
	5	73	810.00	10	950.00	24	540.00		
	6	73	440.00	25	320.00				
	7	73	170.00	12	170.00				
	8	73	100.00	26	91.00				
5559A2	9	72	810.00	23	1800.00				
	10	72	610.00	23	710.00				
	11	72	400.00						
	12	72	200.00	1	260.00	18	170.00		
	1	73	480.00						
	2	73	330.00	11	360.00				
	3	73	630.00	6	720.00				
	4	73	1200.00	8	490.00	20	920.00		
	5	73	770.00	10	900.00	24	510.00		
	6	73	410.00	25	300.00				
	7	73	160.00	12	160.00				
	8	73	97.00	26	85.00				
5559ZZ	9	72	84.00	23	280.00				
	10	72	43.00	23	60.00				
	11	72	25.00						
	12	72	10.00	1	15.00	4	12.00	18	10.00
	1	73	34.00						
	2	73	20.00	11	21.00				
	3	73	48.00	6	54.00				
	4	73	86.00	8	35.00	16	100.00	20	68.00
	5	73	68.00	10	76.00	24	44.00		
	6	73	28.00	25	20.00				
	7	73	9.10	12	9.40				
	8	73	2.90	26	4.10				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/09/30

555901
42 49 00.0 088 12 30.0
TICHIGAN LAKE
55 WISCONSIN

11EPALES 2111202
5 0068 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/21	16 00	0000	18.0	12.0	36	500	9.10	194	0.020	0.030	0.279	0.203
	16 00	0020	15.6	1.2		525	8.50	198	0.040	0.540	0.299	0.263
	16 00	0040	7.3	0.4		545	7.60	195	0.100	2.300	0.610	0.540
	16 00	0060	5.3	0.0		650	7.10	250	0.030	8.400	1.480	1.410
72/08/17	07 50	0000			33	535	8.98	163	0.100	0.110	0.150	0.077
	07 50	0004	23.6	10.0		520	8.95	163	0.100	0.090	0.146	0.081
	07 50	0015	20.0	3.2		570	8.60	183	0.110	0.250	0.165	0.155
	07 50	0025	17.0	0.0		600	8.13	190	0.140	1.100	0.342	0.305
	07 50	0030	11.4	0.0		625	7.60	222	0.090	2.940	0.756	0.658
	07 50	0045	8.3	0.0		650	7.35	232	0.100	4.440	0.886	0.816
	07 50	0055	7.2	0.0		690	7.22	242	0.130	5.580	1.070	1.030
	07 50	0065	6.5	0.0		705	7.10	252	0.090	7.390	1.420	1.320
72/11/10	13 00	0000	7.7			570	8.50	150	0.190	0.560	0.228	0.187
	13 00	0004	7.7	11.1		560	8.50	150	0.200	0.550	0.259	0.190
	13 00	0015	7.7	10.6		560	8.50	148	0.190	0.550	0.258	0.194
	13 00	0025	7.7	11.0		560	8.50	192	0.200	0.540	0.255	0.190
	13 00	0035	7.7									
	13 00	0045	7.7	10.2		560	8.50	182	0.200	0.540	0.226	0.191
	13 00	0055	7.6									
	13 00	0064	7.6	10.4		580	8.40	192	0.230	0.650	0.255	0.208

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/21	16 00	0000	15.4J
72/08/17	07 50	0000	12.1J
72/11/10	13 00	0000	79.9J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/09/30

555902
42 48 00.0 088 13 00.0
TICHIGAN LAKE
55 WISCONSIN

11EPALES 2111202
5 0003 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/21	16 35	0000	18.3	10.4	12	580	8.30	238	0.390	0.030	0.455	0.415
72/08/17	07 30	0000	24.0	5.6	12	600	7.85	232	0.650	0.270	0.505	0.368
72/11/10	12 50	0000				750	7.60	284	1.090	0.090	0.236	0.206
	12 50	0004	6.3	8.9		750	7.60	300	1.190	0.100	0.254	0.202

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/21	16 35	0000	107.1J
72/08/17	07 30	0000	28.9J
72/11/10	12 50	0000	24.7J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 74/10/02

5555941 L5555941
42 45 00.0 086 13 00.0
FOX RIVER
55 15 MILES CORNER
MICHIGAN, LAKE
ST MAY 20 AWDG IN WATERFORD
11FMILES 2111204
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/04/23	13	45	0.777	1.250	0.270	0.225	0.245
72/10/23	14	55	0.850	1.320	0.066	0.230	0.315
72/12/04	15	30	1.700	1.300	0.120	0.260	0.315
72/12/14	15	30	2.200	1.320	0.240	0.430	0.490
73/01/06	16	15	2.060	1.500	0.250	0.185	0.230
73/02/11	14	42	1.430	1.200	0.069	0.140	0.175
73/03/05	15	00	1.240	1.600	0.310	0.154	0.220
73/04/16	09	00	0.740	1.260	0.072	0.105	0.220
73/04/23	14	00	0.280	1.100	0.040	0.091	0.180
73/05/10	14	00	0.270	1.100	0.010	0.147	0.220
73/05/24	11	45	0.210	1.500	0.033	0.210	0.310
73/06/25			0.056	1.600	0.050	0.370	0.545
73/07/12	15	00	0.021	1.700	0.054	0.450	0.630
73/08/26	15	13	0.035	1.500	0.038	0.220	0.360

STORET RETRIEVAL DATE 74/10/02

5559A2 LS555JA2
42 44 30.0 088 14 00.0
FOX RIVER
55 15 HALES CORNER
I/ITICHIGAN LAKE
CO RD BRDG W OF TICHIGAN
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/09/23	14 45		0.289	1.500	0.246	0.190	0.274
72/10/23	15 35		1.020	1.675	0.092	0.290	0.390
72/12/01	14 40		2.040	2.500	0.154	0.260	0.340
72/12/18	16 45		1.900	1.540	0.500	0.410	0.430
73/01/06	14 30		2.300	1.690	0.252	0.149	0.230
73/02/11	14 00		1.160	0.390	0.022		
73/03/06	15 00		1.160	1.050	0.120	0.110	0.165
73/04/08	13 00		0.920	1.020	0.052	0.154	0.230
73/04/20	14 20		0.320	0.960	0.018	0.105	0.155
73/05/10	13 45		0.270	1.000	0.026	0.138	0.190
73/05/24	11 30		0.850	1.320	0.108	0.280	0.360
73/06/25	15 00		0.170	2.420	0.110	0.360	0.461
73/07/12	14 00		0.210	1.980	0.150	0.340	0.490
73/09/24	14 15		1.050	0.750	0.066	0.360	0.410

START WATER YEAR DATE 74/10/01

[illegible]
[illegible] 1555584
[illegible] 00.0 GMT IS 30.0
[illegible] RIVER
[illegible] IS EAGLE
[illegible] CHICAGO, LAKE
CO MAT MI [illegible] SW OF WAUKESHA MELDW STP
[illegible]ERALES
2111204
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3+NO2 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/04/24	13 50		0.707	1.050	0.112	0.190	0.250
73/12/03	04 35		1.700	1.600	0.400	0.540	0.705
73/12/04	13 40		1.520	1.400	0.086	0.357	0.495
73/01/07	15 15		2.100	1.400	0.500	0.300	0.500
73/02/04	15 10		1.700	1.400	0.240	0.240	
73/03/04	15 20		1.563	2.100	0.470	0.260	0.350
73/04/24	14 55		1.520	1.100	0.138	0.120	0.240
73/04/30	09 25		0.860	1.400	0.093	0.180	0.230
73/05/04	15 55		1.020	1.200	0.072	0.176	0.250
73/05/30	17 00		1.000	2.400	0.167	0.320	0.433
73/06/03	04 15		2.040	2.400	0.497	0.357	0.530
73/07/07	17 55		2.040	2.800	0.105	0.400	1.000
73/08/14	15 30		0.503	2.000	0.143	1.470	1.850

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REPORT RETRIEVAL DATE 74/10/02

SSSSAA E555AA
=1 00 30.0 0M 14 30.0
EPA =IVER
S 15 WAUKESHA
LAKE MICHIGAN
ST MAY BE MADE IN WAUKESHA ABOV STP
MILES 2111204
= 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3+NO2 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/06/23	14 05		0.350	1.450	0.110	0.143	0.185
72/12/03	11 35		1.260	1.890	0.510	0.198	0.294
72/12/04	14 20		0.775	1.300	0.100	0.130	0.174
73/01/07	15 00		1.420	1.420	0.420	0.154	0.240
73/02/06	16 20		1.200	1.510	0.220	0.110	
73/03/04	15 04		1.150	1.800	0.350	0.115	0.190
73/04/08	15 10		0.690	1.200	0.200	0.120	0.210
73/04/30	09 40		0.480	1.600	0.077	0.075	0.135
73/05/06	17 35		0.275	1.680	0.088	0.086	0.140
73/05/20	17 35		0.460	2.300	0.140	0.138	0.220
73/06/03	09 25		0.338	2.940	0.210	0.231	0.320
73/07/07	16 15		0.480	1.760	0.054	0.360	0.470
73/08/14	15 10		1.240	1.150	0.044	0.610	0.733

STORET RETRIEVAL DATE 74/10/12

555981 L555981
42 51 30.0 088 19 00.0
MUKWONAGO RIVER
55 15 EAGLE
T/TICHIGAN LAKE
HWY 59E OF MUKWONAGO #FLOSTP
11FWALES 2111204
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N, TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/04/24	14	15	0.114	0.900	0.105	0.039	0.060
72/10/23	14	15	0.570	1.205	0.147	0.126	0.190
72/12/04	14	00	1.300	2.400	0.250	0.150	0.232
72/12/14	14	30	1.400	1.050	0.394	0.144	0.210
73/01/04	15	30	1.120	0.900	0.140	0.058	0.165
73/02/11	14	10	1.220	0.900	0.130	0.110	0.150
73/03/06	15	30	1.100	1.500	0.310	0.075	0.125
73/04/04	13	55	0.970	1.750	0.234	0.086	0.140
73/04/20	13	30	0.350	1.050	0.105	0.050	0.130
73/05/10	13	00	0.420	0.960	0.110	0.052	0.075
73/05/24	10	45	0.440	1.500	0.160	0.165	0.220
73/06/25			0.063	0.900	0.050	0.050	0.065
73/07/12	14	15	0.015	0.810	0.086	0.015	0.031
73/08/28	14	50	0.189	0.990	0.078	0.125	0.165

STORET RETRIEVAL DATE 74/10/02

[illegible] [illegible]
42 51 30.0 084 19 30.0
MUSKEGON RIVER
[illegible] 15 EAGLE
MICHIGAN LAKE
ST HWY 63 BRDG IN MUSKEGON-MUSKEGON STP
11EAGLES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/09/23	15 00		0.054	1.000	0.115	0.0058	0.021
72/10/23	15 00		0.357	0.935	0.074	0.0058	0.015
72/12/04	15 45		1.220	0.600	0.029	0.0058	0.009
72/12/19	16 15		1.340	1.150	0.130	0.0058	0.011
73/01/06	15 15		1.100	0.710	0.050	0.006	0.025
73/02/24	13 52		1.600	2.100	0.140	0.140	0.230
73/03/06	15 24		1.060	1.540	0.196	0.018	0.045
73/04/08	13 45		0.520	0.610	0.054	0.008	0.025
73/04/20	13 00		0.340	0.640	0.043	0.011	0.035
73/05/10	13 15		0.380	0.630	0.017	0.00-	0.020
73/06/25			0.0105	0.620	0.024	0.010	0.020
73/08/26	14 50		0.313	1.030	0.042		0.027

A VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/09/30

555950 TF555950 P040274
43 00 00.0 088 15 00.0
CITY OF WAUKESHA
55 15 WAUKESHA
7/LAKE TICHIGAN
FOX RIVER
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/01/09	00 00								
CP(T)- 73/01/09	24 00		9.100	3.200	0.040	3.800	4.800	10.000	9.250
73/02/06	00 00								
CP(T)- 73/02/06	24 00		6.300	6.700	0.180	4.500	5.350	10.200	9.950
73/03/06	00 00								
CP(T)- 73/03/06	24 00		9.200	1.470	0.490	12.000	12.000	10.900	10.400
73/04/12	00 00								
CP(T)- 73/04/12	24 00		7.300	0.660	0.039	4.000	4.500	11.200	10.600
73/05/10	00 00								
CP(T)- 73/05/10	24 00		7.500	1.600	0.052	2.500	2.800	12.700	11.700
73/06/10	00 00								
CP(T)- 73/06/10	24 00		7.900	0.950	0.180	3.800	3.900	9.820	12.000
73/08/07	00 00								
CP(T)- 73/08/07	24 00		8.700	1.780	0.130	5.400	5.700	9.400	9.300
73/09/05	00 00								
CP(T)- 73/09/05	24 00		7.100	0.620		4.010		9.860	9.500
73/11/06	00 00								
CP(T)- 73/11/06	24 00		3.780		1.900	3.780	4.400	9.690	9.500
73/12/04	00 00								
CP(T)- 73/12/04	24 00		9.800	2.400	0.100	3.900	4.700	9.500	9.300
74/01/15	00 00								
CP(T)- 74/01/16	24 00		10.900	1.200	0.100	4.300	5.100	9.030	9.400
74/02/14	00 00								
CP(T)- 74/02/14	24 00		10.400	2.000	0.190	3.680	4.400	10.000	9.600

16

STORET RETRIEVAL DATE 74/04/10

[illegible]950 TF555950 P040274
43 00 00.0 087 15 00.0
CITY OF WAUKESHA
55 15 WAUKESHA
1/LAKE TICHIGAN
FOX RIVER
11-VALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N+NO2 4-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
74/03/14	09 10								
CP(T)- 74/03/14	24 00		7.300	2.400	0.050	2.500	3.100	12.000	4.600